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March 20, 1862.

Major-General SABINE, President, in the Chair.

The following communication was read :—

“ Suggestions for the Attainment of a Systematic Representation of the Physical Aspect of the Moon.” By John PHILLIPS, M.A., LL.D., F.R.S., Reader in Geology in the University of Oxford. Received January 15, 1862.

I. SKETCH OF THE PROGRESS OF SELENOGRAPHY.

(a) *By Eye-draughts and Micrometry.*

1. Beginning with the labours of Hevelius (1647), maps of the moon, embracing the whole, and signalizing special parts, have been repeated by Riccioli (1651), Cassini (1680), Lalande (1787), T. Meyer (1748), Lambert-Schröter (1791), Lohrmann (1824), Beer and Mädler (1836).

2. The degree in which these laborious efforts may be regarded as meeting the wants of “Selenography,” is about equal to that in which the maps of England of the last century satisfy the requirements of physical geography; and in the same proportion as the great one-inch Ordnance Map of 1862 is superior to the old Chart of 1800, so should be the new drawings of the features of the moon to the older delineations.

3. That such drawings are attainable by the patient employment of modern instruments, in hands capable of good sketching, is, I believe, not doubted by any competent observer with either achromatic or reflecting telescopes having equatorial mounting. If any one doubts, let him compare the Copernicus of Mädler with the Copernicus of Secchi; nay, I may venture to ask that my own Gassendi be placed side by side with that of any of the charts already named.

4. The results likely to be attained by such a series of careful drawings of special parts of the moon’s surface, in one branch of scientific research, are recognized by Mr. Conybeare in his Report on Geology to the British Association in 1832. Indeed, it may be boldly affirmed that a competent theory of volcanic action can hardly

be regarded as having been adequately tested, much less completed, without a careful study of the magnificent volcanic surface of the moon, where for the most part the consolidated products of a long train of igneous eruptions are exhibited as clearly as in the celebrated region of Auvergne.

5. Considerations of this kind pressing upon Lord Rosse, Dr. Robinson, General Sabine, and other persons acquainted with the growing power of telescopes, and the necessity of organizing a system for the use of them on the moon, induced the British Association, assembled at Belfast in 1852, to constitute a Committee, consisting of the Earl of Rosse, the Rev. Dr. Robinson, and Professor Phillips, for the purpose of drawing up a Report on the physical character of the moon's surface as compared with that of the earth.

6. Acting as Secretary to this Committee, Professor Phillips forwarded invitations to fourteen selected observers, in Great Britain and Ireland, the United States, and several localities in Europe, known to be in possession of adequate instrumental power, or willing to provide it. To each observer a certain limited tract was offered, his peculiar work, but everyone was requested to add whatever information he might judge useful relating to other parts of the moon's surface.

7. The answers to these invitations were for the most part favourable as to good intentions; but in several cases want of adequate leisure, sometimes want of health, sometimes other causes were mentioned; and practically it was found that very few of the selected observers sent contributions which fulfilled the wishes of the Committee, even as preliminary surveys. The Secretary of the Committee, indeed, constructed an equatorial of large size for his own share of work, mounted it in the open air, made photographic and eye-drawings, and completed a sketch of his appointed region on the 19th of May, 1853, which sketch has been in the hands of the Royal Society. He thus established, to the satisfaction of several friends, the facility of carrying out the desires of the Committee, and would have taken up fresh districts, on every suitable occasion, but for the change of his residence from York to Oxford. The instrumental mounting being specially fitted for York and the circumstances of his residence there, he was unable to continue his work at Oxford; and several years, as far as this problem is concerned, have

been lost to him for want of an instrument of adequate power and suitable construction, conveniently placed and always at command.

8. Mr. Nasmyth, several years since, employed his fine reflector, with a peculiar apparatus for drawing, in these representations of the moon, which have justly earned for him a reputation in philosophic art of which even the inventor of the steam-hammer may be justly proud. He has lately preferred to use for his eye-draughts a fine achromatic by Cooke, of York,—the same instrument which has been turned with such unexpected results to a scrutiny of the solar spots.

Professor Smyth of Edinburgh, and Professor Challis of Cambridge, made examinations and preliminary sketches of the Mare Crisium, Plato, and other interesting objects; the former artist employing oil-colours in his scene-painting.

(b) *By Photography.*

9. Meantime a new and beautiful art was making itself auxiliary to the delineation of the moon,—first by the silver plate of Daguerre, afterwards by the increasingly sensitive collodion surface. The great achromatic of Cambridge, U.S., under the hands of Bond and Whiffle, gave results of much promise; at first the light-pictures were of the full moon, 2 inches diameter on daguerreotype plates*; afterwards we saw larger representations of the crescent moon, with stronger lights and shadows on the ridges and in the hollows, several inches across (1851–53).

10. While observing with the great reflector at Birr, every one was struck with the probability that almost instantaneous pictures could be obtained of the moon, stars, and planets, by the amazing quantity of light brought to the focus of that magnificent instrument. Some trials had indeed been made in 1852 by the distinguished constructor and Mr. Woods; but I am not aware of the results of later experiments with the great reflector. In 1853 I gave much attention to the use of collodion, and employed an apparatus attached to my achromatic (of 11 feet focus and 6 inches diameter), by which at first pictures of 1·2 inch diameter, and finally others from 2 to 3 inches were obtained, in times gradually reduced from 5' to 30" and less. I still possess many of these pictures; the best, however, was destroyed in attempting to print from it.

* Kosmos, iii. 2. 362.

11. Somewhat earlier than these trials of mine were the first efforts of Mr. De la Rue, of which I was not aware. These efforts have from year to year been rewarded with still increasing success, till we have had from his skilful hands maps of the full moon of positive value, and stereographic pictures of admirable beauty. These researches are still in progress, with every prospect of reaching a point from which eye-draughts may be started on a fresh basis for a systematic scrutiny of all parts of the moon, and the construction of maps on the scale of $\frac{1}{20}$ th of an inch to a mile on the middle part of the moon's face (or as the moon would appear under a power of 1000).

12. Experiments rewarded by considerable success were completed by the Liverpool Photographic Society in 1854 ; and several of their valuable drawings of the moon, magnified to a large scale, were exhibited at the Meeting of the British Association in Liverpool, along with one of mine similarly handled.

II. PROPOSAL OF A METHOD FOR FURTHER PROGRESS.

13. By the labours, for the most part uncombined, of the last ten years, we have not achieved much beyond laying the foundation for further progress. We have acquired, by means of photography, a general view of the whole moon as to its proportions of light and shade, the degrees of light of different parts of its surface, the direction of the light-streaks, and other phenomena, better than eye-draughts and micrometry could furnish.

By eye-draughts and micrometry alone many of the "mountains" and "seas" of the moon have been sketched in beautiful landscapes by Nasmyth and Smyth ; and two "ring mountains" have been surveyed and drawn in detail by Secchi (Copernicus) and Phillips (Gassendi).

The next ten years may, doubtless, be justly expected to give an equal rate of progress ; photographic foundation will be made more effective for the whole moon and for different phases of the moon ; and we may add, by individual and sporadic efforts, a few more ring mountains to our meagre catalogue of objects examined. It appears to me, however, that more than this can be attained, and ought to be attempted, on a plan of continuous work, by means of one instrument devoted to a survey of selected parts of the moon, and I proceed to explain my views.

14. By Mr. De la Rue's exertions principally, photographs of the moon have become an essential element in the desired delineations, and an impression is sometimes felt that by some possible further improvement in that wonderful art, eye-drawing may be dispensed with. This, I am persuaded, can never happen; but there is in my mind the firmest conviction that eye-drawing, founded on a basis of form obtained by photography, will produce results as to details of the moon's peculiarities which light-pictures alone can never reach. For whether the large photographs, on the scale of 100 inches to the moon's diameter, which we desire to obtain, are to be had by enlarging the primary pictures of 1 or 2 inches, or by direct photographs on a larger scale, it seems impossible to escape from some want of definition, by reason of the imperfect surfaces used, or by reason of the inexact following of the moon as she changes her rate or alters her declination. I know this latter error to be very likely of occurrence, even with disks taken beyond the negative eye-piece, with excellent clockwork movement, and am, on this account, the more ready to applaud Mr. De la Rue, whose skillful hands have so well mastered that and other difficulties. I cannot too strongly express my sense of the great value of the light-pictures obtained by that gentleman—as *a basis of form* on which to construct eye-draughts, showing the mind's interpretation of what the eye sees on the moon, but fails to discover in the finest photograph.

15. Reflecting on the comparatively very small degree of success which has rewarded the combination instituted nearly ten years since by the British Association,—remembering that instrumental means have been improved, while the scientific interest in a knowledge of the moon's peculiarities has not diminished,—it appears to me possible to obtain a larger measure of success by a vigorous effort in a different direction. It appears to me that, instead of requesting gentlemen who possess instruments already engaged in other researches to turn them to selenography and make drawings in which they may have no special interest, it will be better to carry a good instrument to an observer interested in the survey of the moon, and willing for a limited time to use his exertions for the accomplishment of a definite object. In my own case I feel sure that this would succeed; and I believe that my case is essentially that of many

intelligent observers of the moon accustomed to extra-meridional observations.

16. The first desideratum then is an Equatorial Instrument, constructed with the conditions of ample optical power,—great steadiness,—delicate adjustment, including a sufficient range for latitude,—the usual circular and micrometrical readings,—clock-movement, &c.,—so that it may be in every point of view adapted for special observations of the moon (sun, planets, comets, &c. may also be observed), and be available for many years, in the same optical and space-measuring condition. According to my view, founded on experience with various instruments, it must be an achromatic, mounted on a transportable solid stand, placed under the roof of a removeable observatory, capable of holding a clock and, if need be, a small transit. The object-glass should be of 6 inches diameter, the focal length 16 or 17 diameters.

Such an instrument has actually been made by my direction; it is finished, and stands complete in the workshop of the skilful artist, whose name is a guarantee of excellence, Mr. T. Cooke of York. Thus the first requisite to give effect to my proposal is practically reached.

17. The second desideratum is that the instrument shall become the property of some scientific body constituted for long endurance, and endowed with so much influence as to be able to give effect and gain adherence to a plan of continuous work, by definite persons, for such periods of time as each in succession may command. The instrument to be confided to each in succession, and mounted in a convenient manner for his use, at his home, during the time appointed. Each observer to furnish, at least once a year, an account of his observations, with drawings on the plan already detailed in the instructions furnished by the Moon Committee of the British Association. At the conclusion of his appointed period of observation, the instrument to be again at the disposal of the scientific body to which it belongs, either to be transferred to another observer, or to be again entrusted to the first observer, according as may seem best for the attainment of the object in view.

18. I entertain no doubt that, after the operation of one or two years, each yielding fruit, there will be no other difficulty of obtaining

suitable observers than the difficulty of choice among several proper persons, who will be glad to give their services. To remove any difficulty as to the first trial, I presume to offer for the first two years my own services at Oxford; having already sketched out a definite plan of work, which has not yet been attempted, and which I believe myself able to accomplish.

19. It would be no part of my plan to take photographs of the moon, but rather to obtain from other observatories the best examples of this kind of work, and devote every available hour to eye-sketching on a large scale of the exact appearance of selected parts of the lunar disk.

The drawings thus made, scrutinized and corrected in succeeding years, would gradually and not very slowly grow up to complete eye-draughts of the moon, under the conditions of sunrise, mid-day, and sunset; and would themselves be again a starting-point for the guidance of even closer scrutiny, with the greatest telescopes and the sharpest eyes.

20. Finally, my proposal, if allowed to make one, would be, that, for the purpose of securing a series of satisfactory drawings of the physical features of the moon, a six-inch achromatic, by Cooke, constructed for the purpose, be purchased out of the funds of the Government Grant Committee, and held by a Board composed of three Members of the Royal Society, to be nominated in the first instance and the number afterwards filled up by the Council of the Royal Society, in trust for the use of observers to be appointed by the Board, each for a limited period, and for a defined area of work: the drawings and observations to be communicated, at least once a year, to the Board. Cost of the instrument not to exceed 320 guineas, of a moveable house not to exceed £50.
